

SLURRY FOR POLISHING COPPER-BASED METAL

BACKGROUND OF THE INVENTION

1. Field of the Invention

5 The present invention relates to a slurry for polishing copper-based metal suitable for a chemical mechanical polishing conducted in a step of forming a buried type copper-based metal interconnection of a semiconductor device.

10 2. Description of the Related Art

 In the formation of a semiconductor integrated circuit such as an ULSI for which progress to attain further miniaturization and more densely spaced arrangement has been gathering more speed, copper is a particularly useful material of the electrical connection for forming the interconnection of good performance and high reliability, because of its low electrical resistance and high resistance against the electromigration and the stress migration.

20 Since it is difficult to work copper into shape by means of dry etching, a copper interconnection is currently formed by so-called damascene method, for instance, in the following way.

 Firstly, a sunken section such as a trench or a connection hole is formed in an insulating film formed on a silicon substrate. Next, after a barrier metal film is

formed on the surface inclusive of the inside of this
sunken section, a copper film is grown by the plating
method so as to fill up this sunken section. Polishing is
then carried out by the chemical mechanical polishing
5 (referred to as "CMP" hereinafter) method until the
surface of the insulating film other than the sunken
section is completely exposed, so that the surface may be
planarized. Thereby, the formation of an electrical
connection section such as a buried copper interconnection,
10 a via plug or a contact plug, which is made of copper
filling the sunken section with a barrier metal film lying
therebetween, is accomplished.

For the CMP slurry used in the formation of a copper
interconnection of this sort, a slurry which contains an
15 oxidizing agent and a polishing material as the main
components and further comprises an organic acid such as
an amino acid or a carboxylic acid, is generally used.

For example, in Japanese Patent Application Laid-
open No. 233485/1995, there is disclosed a polishing agent
20 for a copper-based metal which contains an oxidizing agent
(hydrogen peroxide), polishing grains, water and at least
one type of an organic acid selected from the group
consisting of aminoacetic acid (glycine) and amidosulfuric
acid. Further, it is described therein that, with such a
25 polishing agent being used, through the oxidation effect
of the afore-mentioned oxidizing agent, an oxide layer is

formed, on the surface of copper or copper alloy, to serve as an etching barrier, while this copper or copper alloy is immersed in the agent, and in polishing copper or copper alloy, the removal of the afore-mentioned oxide layer is made mechanically, and the afore-mentioned organic acid facilitates to etch the exposed copper or copper alloy.

Further, in Japanese Patent Application Laid-open No. 83780/1996, there are disclosed a polishing agent which contains an oxidizing agent (hydrogen peroxide), water, benzotriazole or its derivative, a polishing agent containing polishing grains and aminoacetic acid (glycine) and/or amidosulfuric acid; and a polishing method wherein a CMP is carried out using this polishing agent to form a film of copper or copper alloy within a sunken section of a substrate. Further, it is described therein that, by performing the CMP with this polishing agent, a protective film is formed on the film that is to be polished so as to prevent the isotropic chemical etching from occurring, and then the removal of this protective film is made, by mechanical polishing, on the surface of the raised section of the film for polishing, and, thereby, a conductive film of high reliability with little dishing or damage can be formed.

Further, in Japanese Patent Application Laid-open No. 238709/1999, there is disclosed a CMP slurry for copper

polishing, which contains citrate, an oxidizing agent (hydrogen peroxide), a polishing material and 1, 2, 4-triazole or benzotriazole. Further, it is described therein that the use of the CMP slurry can improve the removing rate of copper and the addition of the aforementioned triazole or benzotriazole can raise the planarity of the copper layer.

In recent years, as the semiconductor integrated circuit has been increasingly miniaturized and its arrangement, more densely spaced, the increase in interconnection resistance and further complication of the logic circuits which result from the miniaturization of the interconnection have become problems to be coped with, and the employment of the multi-layered interconnection which can reduce the interconnection length has become more and more spreading. Accompanying the increase in the number of layers through the employment of the multi-layered interconnection structure, however, the unevenness of the substrate surface grows and the difference in level widens. The enlargement of the difference in level, owing to the employment of the multi-layered structure may cause various problems including the short-circuited interconnection and the leakage of current, both of which may be brought about by metal residues left in the sunken section of the upper layer(s) after the CMP, and the focus shift in the step of lithography. Therefore, it is

essential for the slurry not to create substantial dishing
(in other words, to provide a high planarity). Further, in
the multi-layered interconnection, the top layer section
of the interconnection is used for the interconnection for
5 power supply, the interconnection for signal or the
interconnection for clock, and for the sake of lowering
these interconnection resistances to reduce the voltage
change and improve various characteristics, it is required
to make the interconnection trench deep and form thick
10 interconnections. In such a case as a thick copper film
is formed and, then, a copper interconnection is formed,
the polishing amount of copper which is to be removed in
the step of one CMP increases and, thus, the time required
for the step of polishing becomes considerably long,
15 giving rise to a problem of lowering the throughput. As a
result, copper polishing at a higher polishing rate is
strongly demanded.

In general, in order to polish copper at a high
polishing rate, the amounts of components for copper
20 etching such as the oxidizing agent and the acid, which
are contained in the polishing slurry, are made higher to
raise their chemical effects. However, if the chemical
effects of the polishing slurry are too strong, even the
copper formed as the buried section may be etched to
25 create a hollow (dishing), and the reliability for the
electrical connection section such as the interconnection

and the via plug may fall.

Further, with the intention of suppressing dishing in the copper interconnection or the like, if the content of the dishing inhibitor such as benzotriazole or 1, 2, 4-triazole is made too high, the polishing rate (the removing rate) of copper may drop a great deal. Further, there become liable to arise problems that polishing may generate strong vibrations and that, in a state where the barrier metal film is exposed, the interconnection edge damage may grow with the exposed section of the barrier metal film being the starting point.

It is, therefore, difficult to polish copper at a high polishing rate, and, at the same time, prevent the dishing from occurring satisfactorily.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a slurry for CMP, capable of polishing a copper-based metal at a high polishing rate, and preventing dishing well from occurring.

In light of the above problems, the present inventors conducted investigations into the composition of the polishing slurry, paying special attention to the organic acid and the triazole-based compound, and found out that the polishing rate markedly increases when, with an amino acid being employed as the organic acid, the

content ratio of the amino acid to the triazole-based compound is within a specific range. An effect of this sort cannot be seen, if a carboxylic acid, which is widely employed as the organic acid, is used instead. In addition to this, the present inventors found out that, the etching rate with an amino acid being used as the organic acid becomes lower than that with a carboxylic acid being used, and these findings led to the present invention.

Accordingly, the present invention relates to a slurry for polishing copper-based metal containing a silica polishing material, an oxidizing agent, an amino acid, a triazole-based compound and water, wherein a content ratio of said amino acid to said triazole-based compound (amino acid / triazole-based compound (weight ratio)) is 5 to 8.

The present invention can provide a slurry for CMP capable of polishing the copper-based metal film at a high polishing rate and preventing the dishing from occurring satisfactorily.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph showing the relationships between the content ratio of glycine to 1, 2, 4-triazole in the polishing slurry and the polishing rate, and the etching rate.

Fig. 2 is a graph showing the relationship between the pH of the polishing slurry and the polishing rate.

Fig. 3 is a graph showing the relationship between the pH of the polishing slurry and the transmittance
5 variation-ratio thereof.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The preferred embodiments of the present invention are described below.

10 The slurry for polishing copper-based metal according to the present invention contains a silica polishing material (polishing grains), an oxidizing agent, an amino acid and a triazole-based compound.

As a polishing material in the present invention, it
15 is preferable to use a silica polishing material such as colloidal silica or fumed silica, from the viewpoints that it produces few scratches on the polished face and it has excellent dispersion stability. Especially, colloidal silica is preferable because this, in particular, hardly
20 produces scratches, owing to its spherical grain shape and uniform grain size, and besides this is available with a high purity and numerous types of grade for the particle size are also provided.

In respects of the polishing rate, the dispersion
25 stability, the surface roughness of the polished face and the like, the average particle size of the silica

polishing material, measured by the light scattering diffraction method, is preferably not less than 5 nm, more preferably not less than 10 nm and still more preferably not less than 20 nm, but preferably not greater than 100 nm, more preferably not greater than 50 nm and still more preferably not greater than 30 nm.

A content of the silica polishing material to the total amount of the polishing slurry is appropriately set within a range of 0.1 to 50 wt %, taking the polishing efficiency, the polishing accuracy and the like into consideration. In particular, from the viewpoints of the polishing rate, the dispersion stability, the surface roughness of the polished face and the like, it is set preferably not less than 0.5 wt % and more preferably not less than 1 wt %, but preferably not greater than 10 wt % and more preferably not greater than 5 wt %.

An oxidizing agent in the present invention may be appropriately selected from well known water-soluble oxidizing agents, taking the polishing accuracy and the polishing efficiency into consideration. For example, those which may cause little metal ion contamination include peroxides such as H_2O_2 , Na_2O_2 , Ba_2O_2 and $(\text{C}_6\text{H}_5\text{C})_2\text{O}_2$; hypochlorous acid (HClO); perchloric acid; nitric acid; ozone water; peracetic acid; nitrobenzene and organic peroxides. Among these, hydrogen peroxide (H_2O_2) is preferable because it does not contain a metal component

or does not generate a harmful byproduct.

A content of the oxidizing agent to the total amount of the polishing slurry in the present invention is appropriately set within a range of 0.01 to 10 wt %, taking the polishing efficiency, the polishing accuracy and the like into consideration. The content thereof is preferably not less than 0.1 wt% and more preferably not less than 0.2 wt% to achieve a better polishing rate; but preferably not greater than 5 wt% and more preferably not greater than 2 wt% to suppress the dishing and regulate the polishing rate. When the content of the oxidizing agent is too low, the chemical effects of the polishing slurry become small so that the polishing rate obtained may become insufficient or the damage may become liable to happen on the polished face. On the other hand, when the content of the oxidizing agent is too high, the dishing may become liable to happen or copper oxide (CuO) may be excessively formed on the surface of the copper-based metal film, which may bring about, through the inhibition of adsorption of the triazole-based compound, undesirable results such as a lowering of the polishing rate and the rough polished surface.

In the case that hydrogen peroxide is utilized as an oxidizing agent, an excellent polishing slurry can be obtained by adding, for example, an aqueous solution of hydrogen peroxide with a concentration of 30 wt % to a

concentration of 1 to 5 wt % in the slurry (H_2O_2
concentration : 0.3 to 1.5 wt %). Nevertheless, when
such an oxidizing agent relatively susceptible to
deterioration with age as hydrogen peroxide is utilized,
5 it may be possible to prepare separately a solution
containing, together with a stabilizer and the like, an
oxidizing agent at a given concentration, and a
composition which is to provide a prescribed polishing
slurry on addition of the solution containing the
10 oxidizing agent, and then mix them just before use.

An amino acid that the polishing slurry of the
present invention contains is an essential component. If
this amino acid and a triazole-based compound are
contained therein at a specific ratio as described below,
15 the dishing can be well prevented from occurring, and
besides a copper-based metal film can be polished at a
high polishing rate.

An amino acid in the present invention may be added
as a single substance or added as a salt or a hydrate.
20 Examples thereof include arginine, arginine hydrochloride,
arginine picrate, arginine flavianate, lysine, lysine
hydrochloride, lysine dihydrochloride, lysine picrate,
histidine, histidine hydrochloride, histidine
dihydrochloride, glutamic acid, sodium glutamate
25 monohydrate, glutamine, glutathione, glycylglycine,
alanine, β -alanine, γ -aminobutyric acid, ϵ -aminocarproic

acid, aspartic acid, aspartic acid monohydrate, potassium aspartate, calcium aspartate trihydrate, tryptophan, threonine, glycine, cysteine, cysteine hydrochloride monohydrate, oxyproline, isoleucine, leucine, methionine, 5 ornithine hydrochloride, phenylalanine, phenylglycine, proline, serine, tyrosine and valine. It is also possible to add two or more different types of amino acids selected therefrom. Among these amino acids, glycine is preferable in respects of the polishing rate and the suppressing 10 effect on the dishing. Further, as glycine is highly soluble, glycine is preferable also in respect of the production of the polishing slurry, and, in addition to that, glycine is available at a low price so that its use enables the low cost production of the polishing slurry.

15 With regard to a content of the amino acid in the polishing slurry of the present invention, it is essential to set this content in such a way that a content ratio of the amino acid to the triazole-based compound that is to be described below (amino acid / triazole-based compound 20 (weight ratio)) is in a range of 5 to 8. This content ratio is set in a range of preferably 5 to 7.5, more preferably 5 to 7 and still more preferably 6 to 7. When this content ratio is too small, the polishing ratio is lowered. However, when this content ratio is too large, 25 the polishing ratio is again lowered. Further, in this case (in the case the content ratio is too large), namely,

when the amino acid is excess and/or when the triazole-based compound is scarce, the dishing becomes liable to happen.

5 The polishing slurry of the present invention may contain another organic acid other than the aforementioned amino acid as far as the prescribed characteristics are not adversely affected. An addition of an organic acid may facilitate an oxidizing agent to dissolve copper and to carry out polishing stably.

10 Examples of such an organic acid include various carboxylic acids, for instance, oxalic acid, malonic acid, tartaric acid, malic acid, glutaric acid, citric acid, maleic acid, formic acid, acetic acid, propionic acid, butyric acid, valeric acid, acrylic acid, lactic acid,

15 succinic acid, nicotinic acid and their salts.

 The polishing slurry of the present invention further contains a triazole-based compound. By this triazole-based compound, a protective film is formed on the surface of the copper-based metal film, which blocks

20 the etching effect (chemical effect) thereon except at the time of being polished and, thus, prevents the dishing from occurring. Further, as described above, by being contained at a specific ratio to the amino acid, the triazole-based compound can raise the polishing rate.

25 A content of the triazole-based compound in the polishing slurry of the present invention is preferably

not less than 0.05 wt%, more preferably not less than 0.06 wt% and still more preferably not less than 0.07 wt%, but preferably not greater than 0.5 wt%, more preferably not greater than 0.4 wt% and still more preferably not greater than 0.3 wt%. When the content of the triazole-based compound is too low, the etching rate increases and the extent of dishing becomes larger. On the other hand, when the content of the triazole-based compound is too high, the polishing rate drops, although the suppressing effects on the dishing can remain.

A triazole-based compound in the present invention implies triazole or its derivative. Examples of a triazole-based compound include 1, 2, 4-triazole, 1, 2, 3-triazole and their derivatives (substitution products having at least a substituent attached to a carbon atom in the heterocyclic five-membered ring). As examples of a substituent attached to a carbon atom in the heterocyclic five-membered ring of triazole, there can be given hydroxy group; alkoxy group such as methoxy group and ethoxy group; amino group; nitro group; alkyl group such as methyl group, ethyl group and butyl group; and halogen substituent group such as fluorine, chlorine, bromine and iodine, and, herein, it is possible that only one of two carbons in the heterocyclic five-membered ring have a substituent or both carbons have each, either the same type or different substituent. Among these compounds, 1, 2, 4-triazole is

preferable because of its water solubility and its acquisition cost such as price.

A pH value of the polishing slurry of the present invention is set to be preferably in a range of pH 3 to 8, viewed from the points of the polishing rate, the prevention of dishing, the corrosion and surface roughness on the polished face, the viscosity of the slurry and the dispersion stability. Especially, in respects of the polishing rate and the prevention of dishing, pH 5 to 7 is more preferable, and further, with the dispersion stability of the polishing material considered, pH 6 to 7 is more preferable, and pH 6.5 to 7 is particularly preferable. When the pH is too low, the etching power may become strong and the dishing may become liable to happen. On the other hand, when the pH is too high, the effect of the oxidizing agent becomes weaker and, moreover, the handling easiness of the slurry becomes lowered, regarding safety. In addition, when the pH is excessively high, the etching power becomes so strong that the extent of the dishing tends to increase, again.

The pH of the polishing slurry may be adjusted by any well-known method, and examples of an alkali which may be employed for that include alkali metal hydroxides such as sodium hydroxide and potassium hydroxide; alkali metal carbonates such as sodium carbonate and potassium carbonate; ammonia; and amines. Among them, ammonia and

amines which contain no metal component are preferable.

The polishing slurry of the present invention may contain a variety of additives such as a dispersing agent, a buffer agent and a viscosity modifier, which are in wide
5 use as common additives to the polishing slurry, provided that it does not affect adversely the properties of the slurry.

For a method of preparing the polishing slurry of the present invention, an ordinary method of preparing an
10 aqueous polishing slurry composition with free grains can be applied. Specifically, an appropriate amount of a polishing material is added to an aqueous solvent and then, if necessary, with an appropriate amount of a dispersing agent being added, a treatment of dispersion is carried
15 out. In the step of the dispersion, for example, an ultrasonic disperser, a bead mill disperser, a kneader disperser, a ball mill disperser or the like may be used, according to the circumstances.

The CMPs using a polishing slurry of the present
20 invention, for example, conducted, as follows. Firstly, there is provided a substrate, wherein an insulating film is formed and a sunken section in prescribed pattern shape is formed in the insulating film and, thereon, a copper-based metal film is grown. This substrate is placed on a
25 wafer carrier such as a spindle. With a prescribed pressure applied, the surface of this copper-based metal

film in this substrate is made to contact with a polishing pad which is adhered onto a surface plate such as a rotary plate, and while supplying a polishing slurry between the substrate and the polishing pad, the wafer and the
5 polishing pad are moved relative to each other (for instance, both of them are rotated) and thereby the wafer is polished. The polishing slurry may be supplied onto the polishing pad from a supply tube set separately or it may be supplied onto the surface of the polishing pad from
10 the side of the surface plate. If necessary, a pad conditioner may be brought into contact with the surface of the polishing pad to condition the surface of the polishing pad.

The polishing slurry of the present invention
15 described above is the most effective when a sunken section such as a trench or a connection hole is formed in an insulating film laid on a substrate, a copper-based metal film is formed over the entire surface thereof so as to fill up this sunken section with a barrier metal film
20 lying therebetween, and by CMP polishing the copper-based metal film, an electrical connection section such as a buried interconnection, a via plug, a contact and the like is formed. As an insulating film, there can be given a silicon oxide film, a BPSG (Boron-Phosphorous-Silicate
25 Glass) film, a SOG (Spin-on-Glass) film, a SiOF film, a HSQ (Hydrogen Silses-Quioxane) film, a SiOC film, a MSQ

(Methyl-Silses-Quioxane) film, a polyimide film, a Parylene® film (polyparaxylylene film), a Teflon® film and an amorphous carbon film. As a barrier metal film well suited to the copper-based metal film, that is, the copper
5 film or the copper alloy film whose main component is copper, there can be given a tantalum-based metal film made of tantalum (Ta), a tantalum nitride, tantalum silicon nitride or the like.

Examples

10 The present invention is further described in detail below.

CMP Conditions

The CMP was carried out using a polisher SH-24 made by SpeedFam Co., Ltd. The polisher was used, onto a
15 surface plate of which a polishing pad (IC 1400, made by Rodel Nitta Company) with a diameter of 61 cm was attached. Polishing conditions were as follows; a contact pressure of the polishing pad : 27.6 kPa, a polishing area of the polishing pad : 1820 cm², a rotating speed of the surface
20 plate : 55 rpm; a carrier rotating speed : 55 rpm; and a feeding rate of the slurry polishing agent: 100 ml/min.

For a substrate for polishing, a substrate in which a copper film was grown on a Si substrate by the sputtering method was used.

25 Measurement of Polishing Rate

The polishing rate was calculated from the surface

resistivities before and after the polishing as follows.

Four needle electrodes were aligned on the wafer with a given interval, and with a given current being applied between two outer probes, a potential difference between

5 two inner probes was measured to determine a resistance (R'), and further a surface resistivity (ρ_s') was obtained by multiplying that value by a correction factor RCF (Resistivity Correction Factor). A surface resistivity (ρ_s) for another wafer film with a known thickness (T)
10 (nm) was also obtained. Since the surface resistivity is inversely proportional to the thickness, if a thickness for the wafer with the surface resistivity of ρ_s' is taken as d , an equation

$$d \text{ (nm)} = (\rho_s \times T) / \rho_s'$$

15 is given. Using this equation, the thickness d can be determined, and the polishing rate was then estimated by dividing the difference between film thicknesses before and after the polishing by the polishing time. For the measurements of the surface resistivity, a surface
20 resistance detector (Four Probe Resistance Detector, Loresta-GP, made by Mitsubishi Chemical Corporation) was used.

Measurement of Etching Rate

A Si substrate on which a Cu film was grown was
25 cleaved into a size of $1.2 \times 1.2 \text{ cm}^2$ and this was subjected to an immersion in 50 ml of a polishing slurry

at 25 °C for 30 minutes. The surface resistivities (ρ_s') of the Cu film before and after the immersion were measured by the surface resistance detector (Four Probe Resistance Detector, Loresta-GP, made by Mitsubishi Chemical Corporation). Using the afore-mentioned relationship equation " $d \text{ (nm)} = (\rho_s \times T) / \rho_s'$ ", the film thickness after the immersion was obtained and then the etching rate was calculated by dividing the difference between film thicknesses before and after the immersion by the immersion time.

Estimation of Dispersion Stability

Using a self-recording spectrophotometer (U-4000 Type, made by Hitachi, Ltd.), the transmittances of the slurry were measured immediately after the preparation of the slurry and after 3000 hours from the preparation.

Preparation of Polishing Slurry and Results of Estimation

A number of slurries each of which contained 5 wt % of colloidal silica (TSOL Series, made by Tama Chemicals Co., Ltd.; primary particle size : approximately 30 nm), 20 wt % of an aqueous solution of 30 wt % hydrogen peroxide (the amount of H_2O_2 : 0.6 wt %), 1, 2, 4-triazole, glycine and water were prepared. The contents of 1, 2, 4-triazole and glycine in each slurry are listed in Table 1. Further, the pH value of each slurry was adjusted to be within a range of 6.5 to 7 with an aqueous solution of ammonia.

The results of measurements of the polishing rate and the etching rate for each slurry are shown in Table 1 and Fig. 1. These results show that a high polishing rate can be obtained when the content ratio of glycine to 1, 2, 4-triazole (glycine content ratio) is in a specific range. Further, it is clearly seen that the etching ratio increases with higher glycine content ratios. These results indicate that, in order to suppress etching satisfactorily, in other words, in order to prevent dishing from occurring and, at the same time, obtain a high polishing rate, it is preferable for the glycine content ratio to be in a range of 5 to 8, and especially in a range of 6 to 7.

Table 1

Slurry No.	1,2,4-triazole content (wt%)	Glycine content ratio	Polishing Rate (nm/min)	Etching Rate (nm/min)
1	0.075	3	110	0.9
2	0.075	5	249	0.8
3	0.075	7	395	0.8
4	0.075	10	230	2.2
5	0.1	3	120	0.5
6	0.1	5	310	0.6
7	0.1	7	455	0.6
8	0.1	10	280	1.7
9	0.3	3	110	0.5
10	0.3	6	360	0.4
11	0.3	7	370	0.8
12	0.3	10	320	1.8

H₂O₂ content (wt%) : 0.6 wt %

The results of measurements of the polishing rate at a glycine content ratio of 7 with various hydrogen peroxide contents are shown in Table 2. These results demonstrate that even if the content of hydrogen peroxide increases more than necessary, a high polishing rate cannot be obtained and, on the contrary, a decrease in polishing rate may be brought about.

Table 2

Slurry No.	H ₂ O ₂ content (wt %)	1,2,4-triazole content (wt%)	Glycine content ratio	Polishing rate (nm/min)
7	0.6	0.1	7	455
13	0.9	0.1	7	690
14	1.5	0.1	7	450
15	3.0	0.1	7	380

The results of measurements of the polishing rate obtained using slurries with various pH whose glycine content ratio is 6 are shown in Fig. 2. These results indicate that high polishing rates may be obtained at pH 5 to 7.

The results of measurements of the transmittance of the polishing slurry obtained using slurries with various pH whose glycine content ratio is 6 are shown in Fig. 3. The numbers on the ordinate in Fig. 3 indicate variation-ratios of the transmittance measured after 3000 hours from the preparation of the slurry to the transmittance measured immediately after the preparation. These results

indicate that at a pH not less than 6 and especially at a pH not less than 6.5, the slurry shows an excellent dispersion stability.

As Case for Comparison, the results of measurements of the polishing rate and the etching rate for polishing slurries each of which contains benzotriazole in place of 1, 2, 4-triazole contained in each slurry shown in Table 1 are shown in Table 3. These results demonstrate that, with a polishing slurry containing benzotriazole, a high polishing rate cannot be obtained. It is thought that because benzotriazole is liable to be adsorbed strongly to form a firm coating, a high polishing rate cannot be obtained.

Table 3

Slurry No.	Benzotriazole content (wt%)	Glycine content ratio	Polishing rate (nm/min)	Etching rate (nm/min)
16	0.005	3	42	0.9
17	0.005	5	119	0.8
18	0.005	7	122	0.9
19	0.005	10	98	2.5
20	0.01	3	82	0.5
21	0.01	5	178	0.5
22	0.01	7	152	0.6
23	0.01	10	130	1.2
24	0.02	3	57	0.7
25	0.02	5	140	0.8
26	0.02	7	152	0.7
27	0.02	10	85	1.8

H₂O₂ content (wt %) : 0.6 wt %

As Case for Comparison, the results of measurements of the polishing rate and the etching rate for polishing slurries each of which contains tartaric acid or citric acid in place of glycine contained in each slurry shown in Table 1 are shown in Table 4. These results demonstrate that, with a polishing slurry containing a carboxylic acid instead of an amino acid, a high polishing rate cannot be obtained, while suppressing the etching rate.

10 Table 4

Slurry No.	Carboxylic acid	Carboxylic acid content ratio	Polishing rate (nm/min)	Etching rate (nm/min)
28	Tartaric acid	5	110	1.0
29	Tartaric acid	7	145	1.8
30	Tartaric acid	10	180	2.8
31	Citric acid	4	240	10.0
32	Citric acid	7	250	17.0
33	Citric acid	10	320	23.0

H₂O₂ content (wt %) : 0.6 wt % ; 1, 2, 4-triazole content : 0.1 wt %